COLLEGE OF MEDICINE AND HEALTH SCIENCES

DEPARTMENT OF ANESTHESIA AND ANESTHESIOLOGY

INCIDENCE AND PREDICTORS OF HYPOTENSION AFTER SPINAL ANESTHESIA AMONG PREECLAMPTIC MOTHERS WHO UNDERWENT CESAREAN SECTION IN SELECTED TEACHING HOSPITALS OF SOUTHERN ETHIOPIA, 2024: A MULTICENTER PROSPECTIVE COHORT STUDY

PRINCIPAL INVESTIGATOR: ADISU NEGESA (BSC, MSC STUDENT IN CLINICAL ANESTHESIA)

JUNE, 2024

HAWASSA, ETHIOPIA

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A THESIS PAPER SUBMITTED TO HAWASSA UNIVERSITY COLLEGE OF MEDICINE AND HEALTH SCIENCES DEPARTMENT OF ANESTHESIA AND ANESTHESIOLOGY FOR THE PARTIAL FULFILMENT OF THE REQUIREMENTS FOR MASTERS DEGREE IN CLINICAL ANESTHESIA

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This is to certify that the thesis entitled "Incidence and predictors of hypotension after spinal anesthesia among preeclamptic mothers who underwent cesarean section in selected teaching hospitals of southern Ethiopia" submitted in partial fulfillment of the requirements for the degree of Master's with specialization in clinical anesthesia, the graduate program of the Department of Anesthesia and Anesthesiology, and has been carried out by Adisu Negesa ID. No. AnR0001/15, under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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We, the undersigned, members of the Board of Examiners of the final open defense by Adisu Negesa have read and evaluated his thesis entitled "Incidence and predictors of hypotension after spinal anesthesia among preeclamptic mothers who underwent cesarean section in selected teaching hospitals of southern Ethiopia", and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement for the degree.

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ACRONYMS AND ABBREVIATIONS

AOR----------Adjusted Odds Ratio

APGAR----------Appearance, Pulse, Grimace, Activity, Respiration

ASA----------American Society of Anesthesiologists

BHUTH----------Bule Hora University Teaching Hospital

BMI----------Body Mass Index

BP----------Blood Pressure

C/S----------Cesarean Section

CI----------Confidence Interval

COR----------Crude Odds Ratio

CPD----------Cephalo-pelvic Disproportion

DBP----------Diastolic Blood Pressure

DURH----------Dilla University Referral Hospital

HUCSH----------Hawassa University Comprehensive Specialized Hospital

MAP----------Mean Arterial Pressure

MD----------Medical Doctor

NIBP----------Noninvasive Blood Pressure

PE----------Preeclampsia

RCT----------Randomized Clinical Trial

SAB----------Subarachnoid Block

SBP ----------Systolic Blood Pressure

SGS----------School of Graduate Studies

SP----------Spinal Puncture

SPSS----------Statistical Package for Social Sciences

WSUCSH----------Wolaita Sodo University Comprehensive Specialized Hospital

WUCSH----------Worabe University Comprehensive Specialized Hospital

WUNEMMCSH ------Wachemo University Nigist Eleni Mohammed Memorial Compressive Specialized Hospital

YGH----------Yirgalem General Hospital

ABSTRACT

Background: Preeclampsia is the most common cause of fetal and maternal problems in developing nations. The incidence of hypotension after spinal anesthesia in preeclamtic mothers during cesarean section ranges from 7-89%. In patients with severe preeclampsia, anesthesia professionals are frequently discouraged from using spinal anesthesia due to the risk of severe hypotension.

Objectives: To assess the incidence and predictors of hypotension after spinal anesthesia among preeclamptic mothers who underwent cesarean section in selected teaching hospitals in southern Ethiopia.

Methods and materials: A multicenter prospective cohort study was conducted among 140 mothers with preeclampsia in 6 randomly selected teaching hospitals in southern Ethiopia from February 1 to April 30, 2024. Data were entered into Epidata version 4.6 and exported into SPSS version 27 for analysis. The variables with a p-value of <0.25 in the bivariable logistic regression were inserted into the multivariable logistic regression. Multivariable logistic regression analysis identified the independent predictors of hypotension after spinal anesthesia. The degree of association was assessed using the Adjusted Odds Ratio (AOR) with a p-value of <0.05 being considered statistically significant.

Results: The overall incidence of hypotension after spinal anesthesia was 50.7%. The dose of bupivacaine >10 mg (AOR=6.28, 95% CI; 1.96-20.06), spinal puncture to baby delivery duration >10 minutes (AOR=5.0, 95%CI; 1.48-16.86), estimated blood loss >500 ml (AOR=5.24, 95% CI; 1.12-24.46) and duration of surgery ≥40 minutes (AOR=5.81, 95% CI; 1.03-32.55) were identified predictors of hypotension after spinal anesthesia.

Conclusion and recommendation: The incidence of hypotension after spinal anesthesia in mothers with preeclampsia was high. Therefore, professionals must use small doses of bupivacaine, reduce spinal puncture to baby delivery time, minimize blood loss, and decrease surgery duration since they are predictors of hypotension after spinal anesthesia.

Keywords: Spinal anesthesia, hypotension, preeclampsia, cesarean section

1. INTRODUCTION

1.1. Background

Preeclampsia is defined as hypertension with proteinuria or any of the severe features (1). Preeclampsia is a hypertensive condition during gestation. It is characterized by proteinuria and newly developed hypertension (≥140/90 mmHg). It occurs beyond twenty weeks of gestation and typically resolves after 48 hours of fetal delivery. If left untreated, approximately 25% of cases can develop eclampsia, increasing risks for both maternal and fetal morbidity (2, 3).

In developing countries, feto-maternal issues are most commonly caused by preeclampsia. Preeclampsia alone is responsible for 40–60% of maternal mortality in these developing nations. 19% of mothers death in Ethiopia are associated with hypertension during pregnancy (4). Cesarean sections are often recommended since they are the only method to effectively treat preeclampsia (5).

The neuraxial type of anesthesia is a better method of anesthesia for cesarean sections in pregnant mothers with preeclampsia. It reduces the complications associated with general anesthesia. The neuraxial anesthesia choices include epidural anesthesia, combined spinal epidural, and single-shot spinal anesthesia (6).

Regional anesthesia-induced hypotension in uncomplicated preeclampsia with severity features raised concerns based on the intravascular volume that was thought to have contracted. Preeclamptic pregnant mothers typically have efficient compensation for vasodilatation because of their well-preserved or enhanced inotrope. In the unlikely event that substantial hypotension develops, uterine blood flow may be decreased and it may lead to fetal compromise (7).

In pregnant mothers with preeclampsia, a fluid resuscitation before subarachnoid block enhances central venous pressure within the first two minutes. Since there is a risk of pulmonary edema, these preeclamptic mothers don’t get adequate preload fluid before subarachnoid block, as a result, they may be at risk for lower blood pressure after local anesthetic agent administration (8).

1.2. Statement of the Problem

Preeclampsia is a leading cause of morbidity and mortality in obstetrics and it is complicating 3%–8% of pregnancies. Anesthesia professionals face a challenge when dealing with preeclampsia, and there is debate on the most effective anesthetic method for cesarean section in these situations. The incidence of hypotension after spinal anesthesia ranges from 7-89% (9). The most common consequence following spinal anesthesia that is related to maternal morbidity and death in these patients is hypotension (10).

Subarachnoid block (SAB) is frequently avoided by anesthesia providers in mothers with severe preeclampsia due to concerns about severe hypotension that may occur after the procedure (11). Preventive measures like providing preload fluids may increase the risk of hypertension and pulmonary edema in preeclamptic mothers (12).

The use of spinal anesthesia in preeclamptic patients undergoing cesarean sections is controversial among anesthesiologists. It can result in unexpected hypotension after sympathetic block. However, several researchers have employed spinal anesthesia in preeclamptics safely, with positive outcomes for both mothers and newborns (13).

Providing safe anesthesia and maintaining perioperative hemodynamic stability is a challenge in preeclamptic mothers undergoing cesarean section. The former belief that sympathetic blockade after neuraxial anesthesia leads to hypotension with resulting decreased uteroplacental perfusion may be dangerous to the mother and fetus, has prevented the common practice of giving spinal anesthesia to these patients (14).

In preeclamptic individuals, spinal anesthesia may result in severe hypotension and reduced perfusion of the uterus and placenta. Neonates may die as a result of blood pressure decrement after spinal anesthesia that decreases uteroplacental perfusion in preeclamptic women. This may decrease uterine blood flow and lead to fetal compromise before birth during c/s (15).

The results of the studies comparing the incidence and severity of hypotension in pregnant mothers with preterm pregnancy undergoing SAB for cesarean delivery with severe preeclamptic showed that the small uterine mass was not associated with the hypotension and that the altered vascular response, primarily because of humoral factors, was most likely the cause of hypotension (16).

1.3. Justification of the Study

Preeclampsia which affects 5% to 7% of pregnancies is a major cause of morbidity and mortality in both mothers and newborns. Severe preeclampsia frequently results in persistent placental hypo-perfusion. Further reductions in perfusion caused by hypotension following subarachnoid block might not be tolerated by the fetus since the uteroplacental circulation is not auto-regulated. Therefore, reducing the severity of this issue may be possible by identifying the modifiable predictors of spinal anesthesia-induced hypotension.

Different studies report different incidences of hypotension following spinal anesthesia in mothers with preeclampsia. So, it is difficult to prepare management protocol for those pregnant mothers undergoing cesarean delivery under subarachnoid blockage. Previous research has shown contradictory results on the incidences of hypotension in preeclamptic mothers after spinal anesthesia. The reported incidences range from 7-89%.

In clinical practice, we observed that preeclamptic women become more hypotensive after spinal anesthesia. So, identifying the modifiable predictors of hypotension following spinal anesthesia can decrease the degree of this problem. If modifiable predictors of hypotension after subarachnoid block are identified, prevention measures can be taken to reduce the consequences of the hypotension to mother and baby.

The predicting factors of hypotension following spinal anesthesia in preeclamptic pregnant mothers were not well studied. The scope of this research was to determine the incidence of hypotension in preeclamptic mothers and identify its predicting factors to prepare management protocols for these patients to decrease poor feto-maternal outcomes and death.

2. LITERATURE REVIEW

2.1. Incidence of hypotension after spinal anesthesia in preeclamptic mothers during c/s

According to the cohort research conducted by Sivevski A *et al* in 2019 in Macedonia, the BP falls (%) from baseline or incidence of hypotension after spinal anesthesia was 25% in preeclamptic mothers (17). The other study conducted by Nikooseresht M *et al* in 2016 in Iran showed that the incidence of hypotension after spinal anesthesia in preeclamptic mothers who underwent cesarean section was 55.8% (9).

The prospective observational study conducted by Goel L *et al* in India in 2018 concluded that there was a decreased hypotension following spinal anesthesia and less need for vasopressor medication in preeclamptic mothers. They concluded that the incidence of hypotension following spinal anesthesia in preeclamptic mothers was 37.2%. They concluded that spinal anesthesia is the best anesthesia for severe preeclamptic mothers undergoing cesarean section without posing any further risks to the mother or child (14).

According to the cohort study done by Saha *et al* in India in 2013, the incidence of ypotension was 32.3% in preeclamptic pregnant mothers who underwent cesarean section under spinal anesthesia. They concluded that pre-eclamptic pregnant mothers experience hypotension after subarachnoid block (SAB) but less phenylephrine is required for its management (16).

In the prospective cohort study done by Deshpande *et al* in 2014, the frequency and intensity of spinal anesthesia associated with hypotension during cesarean delivery in preeclampsia is associated with complications for mother and baby. The overall incidence of hypotension in preeclamtic patients was 34.3%. Spinal anesthesia seemed to be a useful and safe option and alternative to epidural anesthesia in preeclamptic pregnant mothers if hypotension is prevented and managed properly during cesarean deliveries (18).

According to the observational study conducted by Mendes F *et al* in 2011, the mean drop in systolic blood pressure was 27.5% in the preeclamptic mothers. Diastolic blood pressure decreased by 33.1% (19). According to the prospective cohort research conducted by Mitra M *et al.* in 2016 in India, it was shown that the incidence of hypotension after spinal anesthesia was lower in preeclamptic pregnant mothers (20).

The prospective cohort study conducted by Alemayehu TY *et al* in 2020 in Ethiopia indicated that the incidence of hypotension following spinal anesthesia in preeclamptic mothers who underwent cesarean section was 34.1 %. Since the incidence of hypotension after subarachnoid block is high, it needs proper prevention and management (21). According to the cohort study done by Irfan A. *et al* in Pakistan in 2019, the incidence of hypotension among women undergoing cesarean section was significantly more prevalent among women with a history of pre-eclampsia. The overall incidence of hypotension in preeclamptic women undergoing cesarean section under subarachnoid block was 65.8% (22).

The prospective cohort study conducted by Tamiru SM *et al*. in Mekelle in 2022 found that the frequency of hypotension and the magnitude of alteration in MAP in the first nine minutes post-spinal anesthesia in severely preeclamptic pregnant mothers was 31%. Hypotension in individuals with severe preeclampsia may have been caused by several factors (13).

2.2. Predictors of hypotension after spinal anesthesia in preeclamptic mothers during c/s

The study done by Sivevski A *et al* in 2019 concluded that pregnancy of preeclamptic mothers terminates with lower gestational maturity carrying smaller birth weight neonates (smaller uterine size). Most of these preeclamptic mothers are nulliparous. Hence the risk of aortocaval obstruction is decreased. For the same reasons, the epidural venous plexuses in preeclamptics are less exaggerated, thus leading to a lower cephalic spread of the local anesthetic agents. They also considered that the incidence of spinal anesthesia-induced hypotension might be related to the local anesthetic dose, so a low-dose local anesthetic agent provides a lower incidence of post-spinal hypotension (17).

According to the cohort study conducted by Irfan A *et al* in Pakistan in 2019, the incidence of hypotension among women undergoing cesarean section with spinal anesthesia was high and hypotension was significantly more prevalent among women with a history of pre-eclampsia and increased ASA status. Age, residential status, monthly family income, diabetes, obesity, and type of cesarean section are strong predictors of hypotension. In addition to this, women in active labor while coming for surgery are at high risk for hypotension spinal anesthesia (22).

A prospective cohort study conducted by Tamiru S.M. *et al* in Mekelle in 2022 concluded that aortic venous compression may dilate epidural vessels, promoting cephalic diffusion of local anesthetics, thereby increasing the higher level of spinal block. Aortocaval compression may be at least partially responsible for the increased incidence and severity of hypotension. Therefore, as gestational age increases, the risk of aorticaval compression also increases. Any increase in your baby's delivery time of more than 10 minutes after a spinal puncture can significantly increase the risk of hypotension after spinal anesthesia in preeclamptic mothers (13).

In preeclamptic women, a prophylactic crystalloid bolus before spinal anesthesia increases central venous pressure for less than two minutes. Preeclamptic pregnant mothers are at increased risk of pulmonary edema due to increased capillary permeability, decreased colloid oncotic pressure, increased hydrostatic pressure, and, in some cases, left ventricular dysfunction. So, since an adequate amount of fluid would not be given prophylactically or intraoperatively, preeclamptic patients are at risk for hypotension after spinal anesthesia (8).

According to the prospective cohort study done by Belachew BG et al in Ethiopia in 2023, preoperative antihypertensive medications, increased intraoperative blood loss, prolonged surgery time, higher lever sensory block of local anesthetic agents, intraoperative use of vasodilators and increased local anesthetic dose can increase the risk of hypotension following spinal anesthesia in preeclamptic mothers undergoing cesarean section (23).

Conceptual Framework

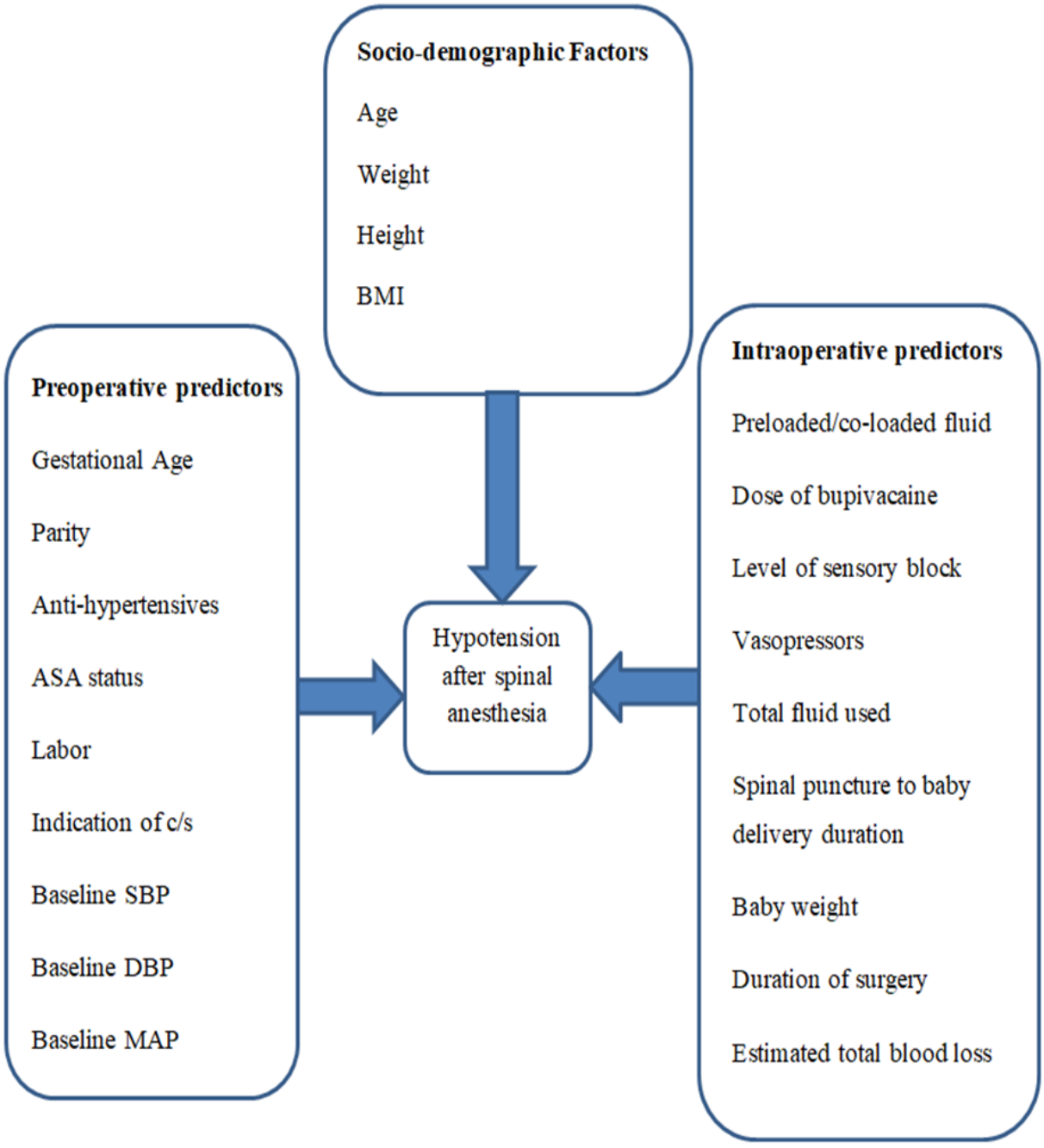

Figure 1: Conceptual framework of possible predictors of hypotension after spinal anesthesia in preeclamptic mothers who underwent cesarean section (9, 16-19, 21, 23, 24).

3. OBJECTIVES

3.1. General Objective:

To assess the incidence and predictors of hypotension after spinal anesthesia among preeclamptic mothers who underwent cesarean section in selected teaching hospitals of southern Ethiopia from February 1 to April 30, 2024.

3.2. Specific Objectives:

To determine the incidence of hypotension after spinal anesthesia among preeclamptic mothers who underwent cesarean section in selected teaching hospitals of southern Ethiopia from February 1 to April 30, 2024.

To identify the predictors of hypotension after spinal anesthesia among preeclamptic mothers who underwent cesarean section in selected teaching hospitals of southern Ethiopia from February 1 to April 30, 2024.

4. METHODS AND MATERIALS

4.1. Study area and period

This research was carried out at 6 randomly selected (with lottery method) teaching hospitals in southern Ethiopia from February 1 to April 30, 2024. The six randomly selected hospitals are Hawassa University Comprehensive Specialized Hospital, Dilla University Referral Hospital, Wachemo University Nigist Eleni Mohammed Memorial Comprehensive Specialized Hospital, Wolaita Sodo University Comprehensive Specialized Hospital, Worabe Comprehensive Specialized Hospital and Bule Hora University Teaching Hospital.

Hawassa University Comprehensive Specialized Hospital (HUCSH), is a tertiary referral academic medical Centre located in Hawassa town, one of the regional cities in Ethiopia (it is the capital city of Sidama region) and located around 275 km from Addis Ababa. It has more than 480 beds which provide service for about 18 million people from Sidama, SNNPR, and neighboring Oromia region, and the daily outpatient flow is more than 300 per day (25).

Wolaita Sodo University Comprehensive Specialized Hospital (WSHCSH) is located in Sodo town of the South Ethiopia Region which is far around 329km from Addis Ababa and this hospital provides general patient services, teaching, and research activities (26).

Dilla University Referral Hospital (DURH) is located in Dilla City administration which is located 360km far away from the capital city, Addis Ababa, in the South of Ethiopia. It is a public hospital that is an affiliate of Dilla University providing Training for medical and health sciences students in a range of disciplines. Furthermore, the hospitals offer about a million populations in the catchment area, a superior quality clinical area (27).

Wachamo University Nigist Eleni Mohammed Memorial Comprehensive Specialized Hospital (WUNEMMCSH) is one the government hospitals located approximately 230km South of Addis Ababa, in Hosanna town, the administer center of the Hadiya Zone and central Ethiopia Region (28).

Bule Hora University Teaching Hospital (BHUTH) located in Bule Hora town, which is 475 km far from Addis Ababa. The hospital is the largest in the West Guji Zone and provides healthcare services to over 1.3 million catchment population (29).

4.2. Study Design

A multicenter prospective cohort study

4.3. Population

4.3.1. Source Population

All preeclamptic mothers undergoing cesarean section in selected teaching hospitals of southern Ethiopia.

4.3.2. Study population

All preeclamptic mothers fulfilled the inclusion criteria within the study period.

4.4. Inclusion and exclusion criteria

4.4.1. Inclusion criteria:

- ✓ Both emergency and elective preeclamptic mothers with ASA physical status II and III
- ✓ Women carrying a singleton

4.4.2. Exclusion Criteria:

Patients with chronic hypertension, renal or cardiac disease, eclampsia, women who have sensitivity to local anesthetics

4.5. Sample size determination and sampling procedure

The sample size for the study was determined using a single population proportion method by using a previous study done in Ethiopia which has an incidence of hypotension after spinal anesthesia of 47% (23). The calculation was based on a 95% confidence level, a 5% margin of error, and an addition of 10% for incomplete or contingency data.

$$n = \frac{(z\alpha/2)^2 \times (p \times q)}{d^2}$$

$$n = \frac{1.96^2 \times (0.47 \times 0.53)}{0.05x0.05} = 383$$

Utilizing the finite population correction formula, the final sample size (nf) was determined using the formula nf = n / (1 + n / N), where nf represents the final sample size, n is the minimum sample size, and N is the total number of preeclamptic patients underwent cesarean section in past 3 consecutive months. The situational analysis revealed that in the past three months, the respective totals from the surgery logbooks of HUCSH, WSUCSH, WUNEMMCSH, DURH, WCSH, and BHUTH were 35, 34, 31, 31, 30, and 29 respectively, totally 190 patients.

nf= n/1+n/N= 383/1+383/190= 127, Adding 10% contingency = 140

Sampling Procedure

Six study areas were randomly selected with a lottery method from nine southern Ethiopia teaching hospitals. The selection of participants was carried out with a consecutive sampling technique. Ultimately, the sample size was proportionally distributed among the hospitals considering their average three-month reports. A calculated sample size of **140** was proportionally allocated. The distribution was as follows: HUCSH received 26, WSUCSH received 25, and WUNEMMCSH received 23, DURH received 23, WCSH received 22, BHUTH received 21 samples, ensuring a representative and balanced sampling approach.

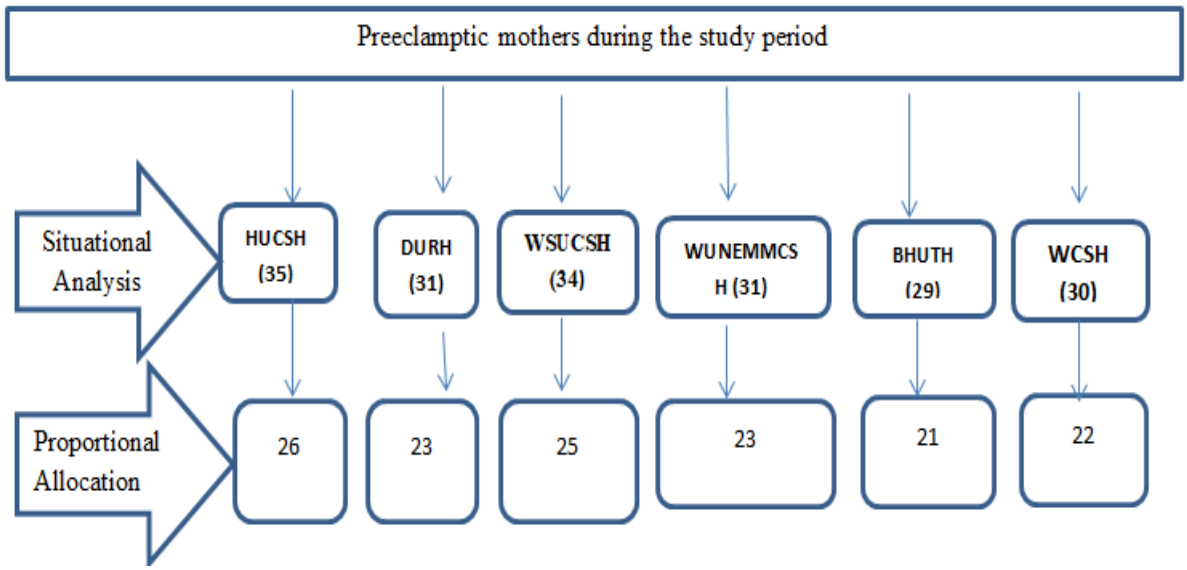

Figure 2: Proportional allocation for sample size

4.6. Variables

4.6.1. Dependent variable

Hypotension after spinal anesthesia

4.6.2. Independent variables

Socio-demographic characteristics (Age, Weight, Height, BMI)

Preoperative predictors

Gestational age

Parity

ASA physical status

Antihypertensive medication

Indication of cesarean section

Labor, baseline SBP, baseline DBP, and baseline MAP

Intraoperative predictors

Amount of preloading or co-loading fluid

Dose of bupivacaine

Level of sensory block

Intraoperative vasopressor used

Total amount of fluid used intraoperatively

Spinal puncture to baby delivery duration

Baby weight

Blood loss

Duration of surgery

4.7. Data Collection Procedures

Data was collected by a structured questionnaire adapted from previous studies (9, 13, 21, 23) from preeclamptic mothers who underwent cesarean section, their medical charts and direct follow-up records of their blood pressure during surgery. Information about the study benefits, harm, and objective of the study was prepared in English and then translated to Amharic, and was explained to the study participants before surgery. Consent was taken from each patient chosen for the study, and they were given instructions on how to self-report pain during pinprick stimulation. For each data collecting center, a supervisor and two trained data collectors were assigned to be involved in the data collection procedure. Sociodemographic data like age, weight, height, and BMI were collected from patients' medical records. Other information like gestational age, number of parity, ASA status, anti-hypertensive medications, labor, and indication for surgery were obtained from the mothers and their medical records. Other intraoperative factors like the amount of preloading or co-loading fluid, dose of local anesthetic, level of sensory block, intraoperatively used vasopressor, the total amount of fluid used intraoperatively, spinal puncture to baby delivery duration, baby weight, estimated blood loss, duration of surgery were directly recorded by data collectors. Assessments of blood pressure parameters were made at three-minute intervals for the first twenty minutes and then at five-minute intervals until 45 minutes (23).

4.8. Data Quality Management

Training was provided for data collectors and supervisors. To assure the quality of data, a structured questionnaire was pretested on 5% of the sample size at Yirgalem General Hospital before actual data collection. The Cronbach's alpha value was 0.78 (78%). Supervision and follow-up were conducted regularly during the data collection process. Supervisors checked out every questionnaire with further cross-checking the by principal investigator for completeness and consistency of data.

4.9. Data Entry and Analysis

Data were checked for completeness, coded, and entered into Epi Data software version 4.6 and exported into SPSS version 27 software for computing data analysis. Descriptive categorical data were summarized by using frequency and percent. The normality of the distribution was examined using the Shapiro-Wilk test and Kolmogorov-Smirnov test. The mean and standard deviation were used to present normally distributed continuous data.

The tables, figures, and text were used to present the data. The chi-square test was used to analyze the categorical variables. Binary logistic regression was conducted to identify the predictors of hypotension after spinal anesthesia among pregnant mothers with preeclampsia. Bivariable logistic regression was fitted to select the candidate variables for multivariable logistic regression and to obtain the crude association (Crude Odds Ratio). The variables with a p-value of less than 25% in the bivariable logistic regression were inserted into the multivariable logistic regression. Before the final model, multicollinearity was checked by variance inflation factor (VIF) and Tolerance test. The Hosmer and Lemeshow goodness of fit test was done to check the model's fitness. Multivariable logistic regression analysis was conducted to identify the independent predictors of hypotension after spinal anesthesia among pregnant mothers with preeclampsia. In the final model, the Adjusted Odds Ratio (AOR) was used to measure the strength of association between dependent and independent variables, and a 95 % confidence interval was used to identify statistically significant predictors at a p-value of <0.05.

4.10. Operational Definitions

Preeclampsia: Defined as a systolic blood pressure (SBP) of ≥140 mm Hg, a diastolic blood pressure (DBP) of ≥90 mm Hg using noninvasive blood pressure measurement (NIBP) and urine dipstick plus one or two, which is recorded from the patient's chart (30).

Mild preeclampsia: Defined as blood pressure <160/110 mmHg (31).

Severe preeclampsia: Defined as blood pressure ≥160/110 mmHg (31).

Hypotension: Defined as greater than 25% decrease in the mean arterial blood pressure after spinal anesthesia from the baseline measurement (9).

4.11. Ethical Considerations

Ethical clearance and approval were obtained from the Hawassa University College of Medicine and Health Sciences institutional review board (Ref No. IRB/059/16). The obtained data were used for study purposes. Confidentiality and anonymity were ensured.

5. RESULTS

5.1. Sociodemographic characteristics of the study participants

A total of 140 preeclamptic mothers who fulfilled the inclusion criteria were enrolled in this study with a 100% response rate. Three-fourth of the study participants were in the age range of 20 to 34. Nearly one-third were overweight, while 38.6% were obese (Table 1).

Table 1: Socio-demographic characteristics of preeclamptic mothers who underwent cesarean section under spinal anesthesia in selected teaching hospitals of southern Ethiopia, February to April 2024 (n=140)

Variable	Category	Frequency (n=140)	Percentage (%)
Age	<20	20	14.3
	20-34	105	75
	>35	15	10.7
BMI	<25	41	29.3
	25-30	45	32.1
	>30	54	38.6

5.2. Preoperative predictors

In the present study, greater than half of the study participants were ASA II (57.9%) whereas more than two third of them were multi-para (67.2%). For more than half of the study participants, the indication for cesarean section was preeclampsia with/without severity features (57.9%). More than one-third of study participants were in labor while coming for cesarean section. Magnesium sulfate was given to 62.1% of patients. The average gestational age was 37±1.76 weeks. The average fluid used for preload was 560±194 ml (Table 2).

Table 2: Preoperative predictors of preeclamptic mothers who underwent c/s under spinal anesthesia in selected teaching hospitals of southern Ethiopia, from February to April 2024 (n=140)

Variables	Category	Frequency, n=140	Percentage (%)
Parity	Null para	46	32.8
	Multi-para	94	67.2
ASA	II	81	57.9
	III	59	42.1
Indication for C/S	Preeclampsia w/without SF	81	57.9
	CPD	7	5.0
	Previous C/S scar	34	24.3
	Mal-presentation	12	8.5
	Others	6	4.3
Labor	Yes	51	36.4
	No	89	63.6
Baseline SBP	Mild	85	60.7
	Severe	55	39.3
Baseline DBP	Mild	52	37.1
	Severe	88	62.9
Baseline MAP	Mild	93	66.4
	Severe	47	33.6

Others: Fetal bradycardia, failed induction, cord prolapse, post-term, fetal tachycardia

5.3. Intraoperative predictors

Out of 140 study participants, 54.3% of patients took >10 mg of bupivacaine for spinal anesthesia. T6 was the highest sensory block for more than half of the participants (52.9%). For 50.7% of participants, spinal puncture to baby delivery duration was greater than 10 minutes. The baby weight of the majority of participants (80.7%) was between 2500-4000g. Adrenaline was used to manage hypotension in 10.7% of patients. The average fluid used during surgery was 2000±436 ml. The estimated blood loss was greater than 500 ml in 54.3% of study participants. For 42.1% of patients, duration of surgery was greater than 40 minutes (Table 3).

Table 3: Intraoperative predictors of preeclamptic mothers who underwent c/s in the selected southern Ethiopia teaching hospitals, February to April 2024 (n=140)

Variable	Category	Frequency, n=140	Percentage
Dose of bupivacaine	≤10 mg	64	45.7
	>10mg	76	54.3
Level of sensory block	T4	14	10
	T5	26	18.6
	T6	74	52.9
	T7	20	14.3
	Other	6	4.2
Spinal puncture to baby delivery duration	≤10 minutes	69	49.3
	>10 minutes	71	50.7
Baby weight	<2500 g	50	35.7
	2500-4000g	70	50
	>4000 g	20	14.3

Estimated blood loss	≤500 ml	64	45.7
	>500 ml	76	54.3
Duration of surgery	≤30 minutes	45	32.1
	30-40 minutes	36	25.7
	≥40 minutes	59	42.2

5.4. Incidence of Hypotension after spinal anesthesia

In the current study, the incidence of hypotension after spinal anesthesia in preeclamptic mothers was 50.7% (95 % CI, 43.6-57.9).

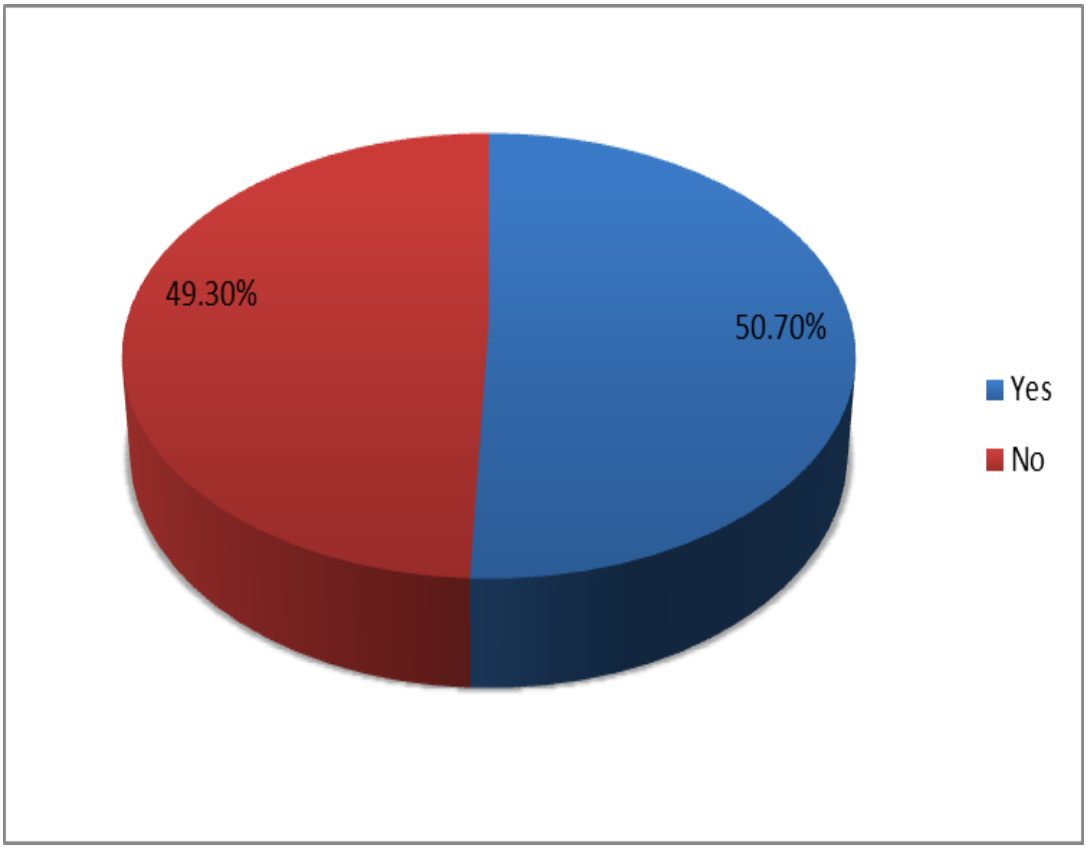

Figure 3: Incidence of hypotension after spinal anesthesia among preeclamptic mothers who underwent cesarean section in selected southern Ethiopia teaching hospitals, 2024 (n=140)

Table 4: Socio-demographic characteristics of preeclamptic mothers who underwent c/s vs hypotension after spinal anesthesia using cross tabulation, from February to April 2024 (n = 140).

Variable	Category	Frequency (%) (n=140)	Hypotension	
			Yes(n=71)	No(n=69)
Age	<20	20(14.3)	11(55)	9(45)
	20-34	105(75)	55(52.4)	50(47.6)
	>35	15(10.7)	5(33.3)	10(66.7)
BMI	Normal	41(29.3)	15(36.6)	26(63.4)
	Overweight	45(32.1)	18(40.0)	27(60.0)
	Obese	54(38.6)	40(74.1)	14(25.9)

Table 5: Preoperative predictors of preeclamptic mothers who underwent c/s vs hypotension after spinal anesthesia using cross tabulation, from February to April 2024 (n = 140).

Variables	Category	Frequency (%) n=140	Hypotension	
			Yes(n=71)	No(n=69)
Parity	Null para	46(32.9)	27(58.7)	19(41.3)
	Multi-para	94(67.1)	44(46.8)	50(53.2)
ASA	II	81(57.9)	37(45.7)	44(54.3)
	III	59(42.1)	34(57.6)	25(42.4)
Indication for C/S	Preeclampsia w/without SF	81(57.9)	44(54.3)	37(45.7)
	CPD	7(5.0)	3(42.9)	4(57.1)

	Previous C/S scar	34(24.3)	15(44.1)	19(55.9)
	Mal-presentation	12(8.6)	6(50)	6(50)
	Others	6(4.2)	4(66.7)	2(33.3)
Labor	Active	51(36.4)	24(47)	27(53)
	Not Active	89(63.6)	47(52.8)	42(47.2)
Baseline SBP	Mild	85(60.7)	37(43.5)	48(56.5)
	Severe	55(39.3)	34(61.8)	21(38.9)
Baseline DBP	Mild	52(37.1)	23(44.2)	29(55.8)
	Severe	88(62.9)	48(54.5)	40(45.5)
Baseline MAP	Mild	93(66.4)	43(46.2)	50(53.8)
	Severe	47(33.6)	28 (59.6)	19(40.4)

Others: Fetal bradycardia, failed induction, cord prolapse, post-term, and fetal tachycardia

Table 6: Intraoperative predictors of preeclamptic mothers who underwent c/s vs hypotension after spinal anesthesia using cross tabulation, from February to April 2024 (n = 140).

Variable	**Category**	**Frequency (%)**	**Hypotension (n=140)**	
			Yes(n=71)	**No(n=69)**
Dose of bupivacaine	≤10 mg	64(45.7)	14(21.9)	50(78.1)
	> 10mg	76(54.3)	57(75.0)	19(25.0)
Level of sensory block	T4	10(7.1)	7(70)	3(30)
	T5	26(18.6)	19(73.1)	7(26.9)
	T6	74(52.9)	40(54.1)	34(45.9)
	T7	20(14.3)	8(40)	12(60)
	T8	10(7.1)	3(30)	7(70)

SP to baby delivery duration	≤10 minutes	69(49.3)	16(23.2)	53(76.8)
	>10 minutes	71(50.7)	55(77.5)	16(22.5)
Baby weight	<2500 g	50(35.7)	20(40)	30(60)
	2500-4000g	70(50)	34(48.6)	36(51.4)
	>4000 g	20(14.3)	14(70)	6(30)
Estimated blood loss	≤500 ml	65(46.4)	13(20)	52(80)
	>500 ml	75(53.6)	58(77.3)	17(22.7)
Duration of surgery	≤30 minutes	44(31.4)	11(25.0)	33(75.0)
	30-40 minutes	42(30)	13(31.0)	29(69.0)
	≥40 minutes	54(38.6)	47(87.0)	7(13.0)

The incidence of hypotension following spinal anesthesia was highest at the 12th minute of spinal anesthesia administration. Among 50.7% the participants who developed hypotension following spinal anesthesia, 21.1% of them developed hypotension at the 12th minute followed by the 9th minute which had an incidence rate of 16.9%.

On the other hand, 12.7% of the participants developed hypotension after a subarachnoid block at the 45th minute of spinal anesthesia. After the 15th minutes of spinal anesthesia administration, the incidence of hypotension after spinal anesthesia starts to decrease at which probably the mothers delivered. So, the incidence of hypotension after spinal anesthesia was high immediately after spinal anesthesia and after a prolonged duration of surgery (Figure 4).

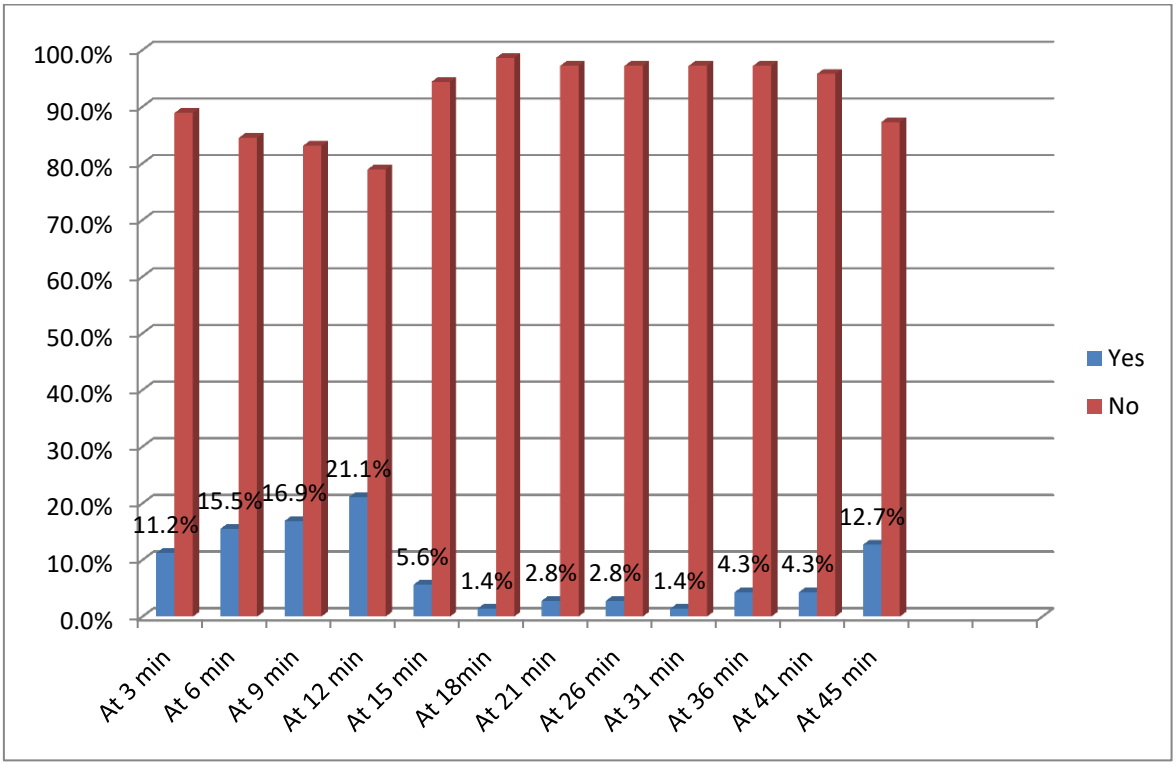

Figure 4: Proportion of incidence of hypotension after spinal anesthesia in preeclamptic mothers who underwent cesarean section during the follow-up time

5.5. Predictors of hypotension after spinal anesthesia

The bivariate logistic regression was fitted to identify the factors associated with hypotension after spinal anesthesia in pregnant mothers with preeclampsia. Accordingly, ASA, number of parity, Baseline systolic blood pressure, baseline diastolic blood pressure, baseline mean arterial pressure, dose of bupivacaine, spinal puncture to baby delivery duration, estimated blood loss during surgery, and duration of surgery showed association with hypotension after spinal anesthesia at a P value of <0.25.

On multivariable logistic regression, a dose of bupivacaine >10 mg were 4.6 times more likely to cause hypotension after spinal anesthesia. Spinal puncture to baby delivery time >10 minutes was 6.4 times more likely to cause hypotension. Estimated blood loss >500 ml and duration of surgery ≥40 minutes was 6.7 and 5.5 times more likely to cause hypotension respectively (Table 7).

Table 7: A multivariable logistic regression analysis showing predictors of hypotension after spinal anesthesia among preeclamptic mothers who underwent c/s in selected teaching hospitals of southern Ethiopia, February to April 2024 (140)

Variable	Category	Hypotension n=140		COR(CI)	AOR(CI)	p-value
		Yes(71)	No(69)			
Parity	Nulliparous	27	19	1.615(0.79-3.29)	0.612(0.18-2.00)	0.418
	Multipara	44	50	1	1	
ASA	II	37	44	1	1	
	III	34	25	1.617(0.82-3.18)	1.47(0.50-4.31)	0.477
Baseline SBP	Mild	37	48	1	1	
	Severe	34	21	2.10(1.05-4.19)	1.48(0.47-4.66)	0.495
Baseline DBP	Mild	23	29	1	1	
	Severe	48	40	1.51(0.76-3.01)	0.25(0.06-1.00)	0.051
Baseline MAP	Mild	43	50	1	1	
	Severe	28	19	1.71(0.84-3.49)	1.26(0.40-3.88)	0.688
Dose of bupivacaine	≤10 mg	14	50	1	1	
	>10 mg	57	19	10.7(4.87-23.55)	4.6(1.56-13.88)	0.006
SP to baby delivery	≤10 minutes	16	53	1	1	
	>10 minutes	55	16	11.4(5.17-25.06)	6.48(1.89-22.17)	0.003
Estimated blood loss	≤500 ml	13	51	1	1	
	>500 ml	58	18	12.6(5.64-28.31)	6.74(1.43-31.81)	0.016

Duration of surgery	≤30 min	11	34	1	1	
	30-40 min	13	23	1.74(0.66-4.57)	0.46(0.94-2.27)	0.341
	≥40 min	47	12	12.1(4.77-30.66)	5.49(1.07-29.63)	0.048

Key: AOR adjusted odds ratio, COR crude odds ratio, CI confidence interval.

6. DISCUSSION

Hypotension following spinal anesthesia in mothers with preeclampsia may be caused by the sudden onset of sympathetic blockade, underlying intravascular volume depletion, or potential left ventricular dysfunction. This study assessed the incidence of hypotension and its predictors following spinal anesthesia in preeclamptic mothers who underwent cesarean section in selected teaching hospitals in southern Ethiopia, in 2024.

In the current study, the overall incidence of hypotension after spinal anesthesia in preeclamptic mothers during cesarean section was 50.7% (95 % CI, 43.6-57.9). This result is consistent with studies conducted by Belachew BG *et al* in Ethiopia (47%) (23), and Nikooseresht M *et al* in Iran (55.8%) (9).

This result is higher than the study conducted by Alemayehu TY et al in Gondar which reported the incidence of hypotension to be 34.1%. (21). The possible explanation for this discrepancy in findings may be the use of different criteria for defining hypotension (20% versus 25% decline to baseline MAP). The finding of the present study is higher than a study conducted by Tamiru SM *et al* in Mekelle, which found an incidence of 31% (13). This may be due to the average gestational age in our population being higher when compared with their population (35.5 ± 1vs 37±1.76 weeks). This result is also higher than the study conducted by Sivevski A *et al* in Macedonia which reported the incidence of hypotension to be 25% (17). The possible explanation for this discrepancy may be due to they used only a lower dose of local anesthetic agent in their study.

On the other hand, our result is lower than the study conducted by Khatri RK *et al* in India, which found the incidence of hypotension in preeclamptic pregnant mothers 60% (32). This discrepancy may be due to the lower mean intra-operative crystalloid consumption in their population when compared with our population (1330 ± 744.36 ml vs 2000 ± 436 ml). The other study conducted by Mendes F *et al* in Brazil reported an incidence of 84% (19). This discrepancy may be due to the small sample size and usage of hydralazine for all patients whose DBP was higher than 90 mmHg.

In the current study, the use of high-dose bupivacaine for spinal anesthesia is significantly associated with hypotension after spinal anesthesia. We compared the effect of low-dose bupivacaine (≤10 mg) with high dose (>10 mg) and these patients who were given high

dose bupivacaine developed hypotension 4.6 times (AOR, 4.6; 95% CI; 1.56-13.88) more likely than those pregnant mothers with preeclampsia who were given low-dose bupivacaine. This result is consistent with the study conducted in Ethiopia, Macedonia, and Iran. The possible explanation for this may be as the local anesthetic agent dose increases, the distribution of local anesthetic increases and higher level sympathetic blockage occurs (9, 17, 23).

In the present study, pregnant mothers with preeclampsia who experienced spinal puncture to baby delivery duration >10 minutes developed post-spinal anesthesia hypotension 6.4 times (AOR, 6.4; 95% CI; 1.89-22.17) more likely than those delivered before 10 minutes of spinal puncture to baby delivery. This finding is in line with the study conducted by Fakherpour *et al* in Iran. Hypotension is more likely to occur when a longer time elapses between the spinal puncture and the skin incision. One possible explanation is that pregnant women stay more time in the supine position before giving birth. As the amount of time between spinal puncture and baby delivery increases, the risk of hypotension is increased. The increase in the aortocaval compression duration as well as the sympathetic blockade exacerbates hypotension after spinal anesthesia (33).

Estimated blood loss during surgery was another predictor of hypotension after subarachnoid block according to the result of our study. Patients who lost >500 ml of blood during surgery developed hypotension after spinal anesthesia 6.7 times (AOR, 6.7; 95% CI; 1.43-31.81) more likely than those who lost ≤ 500 ml. This result is consistent with other studies conducted in Ethiopia (23). One explanation for this could be that significant blood loss, like that occurs after surgery lowers blood volume, which causes a sharp decline in blood pressure. A decrease in blood volume causes the arteries to contract, the pressure drops, and the perfusion pressure drops.

In our study, duration of surgery is the predictor of hypotension following spinal anesthesia. The risk of hypotension after spinal anesthesia during the duration of surgery more than 40 minutes was 5.5 times (AOR, 5.5; 95% CI; 1.07-29.63) more likely than the duration of less than 30 minutes. This result is in line with the study conducted in Benin (34). The possible explanation for this might be that, as the duration of surgery increases, the blood loss and oxytocin infusion can decrease the blood pressure.

Strengths and Limitations of the Study

Strength

- Data were collected by trained Anesthetists and there was close supervision
- The study was conducted in multi-center
- No loss to follow-up of patients

Limitations

- A small sample size.
- The study participants were selected consecutively.
- Lack of invasive blood pressure measurement
- Oxytocin infusion was not controlled
- Speed for spinal anesthesia administration was not controlled

7. CONCLUSION AND RECOMMENDATION

7.1. Conclusion

The incidence of hypotension after spinal anesthesia was found to be high. Among the studied predictors of hypotension after spinal anesthesia, high dose bupivacaine, increased spinal puncture to baby delivery duration, increased blood loss during surgery, and prolonged surgery duration were identified as significant predicting factors for hypotension after spinal anesthesia in pregnant mothers with preeclampsia who underwent cesarean section.

7.2. Recommendation

Depending on our study findings, we recommend the following:

1. **Clinicians**

Our findings indicate that the dose of bupivacaine was a predictor of hypotension after spinal anesthesia. As a result, it is crucial to use low-dose bupivacaine to minimize the risk of hypotension after spinal anesthesia.

Clinicians should work to reduce the spinal puncture to baby delivery time and surgery duration. Estimated blood loss also should be minimized by using different methods like using tranexamic acid, positioning, and permissive hypotension.

2. **Institution**

The hospital administration should recognize the severity of the issue and make plans for effective measures, such as mobilizing resources or increasing the clinicians' knowledge through regular training for responsible health professionals.

3. **Researchers**

We recommend researchers do multicenter further more detailed studies with high-quality study design or RCT on this topic with a large sample size.

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9. ANNEXES

9.1. Annex I: English Version Informed Consent

Name of the institute_____Address of the institute_____

Dear participant greeting; I'm _____; I am a second-degree student at Hawassa University. I am conducting my research entitled 'Incidence and predictors of hypotension after spinal anesthesia in preeclamptic mothers undergoing cesarean section at selected teaching hospitals of southern Ethiopia, 2024: a multicenter prospective cohort study'. The information gathered will assist medical practitioners and other relevant organizations in lowering the incidence of hypotension and identifying its predictors, both of which lower maternal and newborn morbidity and mortality. You may be the one taking part in the research. For this reason, to fulfill the study's purpose, we respectfully ask for your participation in the study and your reaction. Your answer will be kept private, and you are free to decline any question at all or to withdraw from the study altogether. On the other hand, we will be able to assess and comprehend the effect of your possible answers to those questions. We therefore ask that you respond honestly and continue to participate.

Would you a willing to participate in the study, please?
YES_____NO_____

Thank you so much!!!!

For further information you can
communicate with investigator

Tele - +251926437399
Email:nagesaaddisu@gmail.com

Informed consent verified by an interviewer

Interview date_____Card number_____

Interviewer's name_____Signature_____

Supervisor's name_____Signature_____

Date of check-in_____

9.2. Annex II: Amharic version consent form

የስምምነት ቅጽ

የተቋሙ ስም_____የተቋሙ አድራሻ_____

የተከበሩ የጥናቱ ተካፋይ ጤና ይስጥልን፤ እኔ_____እባላለሁ፡፡ በሀዋሳ ዩኒቨርሲቲ በአንስቴዝያ ትምህርት ክፍል የሁለተኛ ዲግሪ ተማሪ ስሆን በቀዶ ጥገና ወሊድ ጊዜ የአንስቴዝያ መድሀኒት በሚሰጥበት ግዜ የወሊድ ጊዜ ከፍተኛ የደም ግፊት ያላቸዉ እናቶች ላይ ደም ግፊታቸዉን የሚቀንሱ ነገሮች ላይ የሚሰራ የመመረቅያ ጥናት እየተመራመርኩኝ ሲሆን፤ ጥናቱ ለእርሶ ምንም አይነት የገንዘብ ጥቅም አያስገኝም፤ ነገር ግን የጥናቱ ውጤት በህክምና ዘርፍ ላይ ያሉትን ችግሮች ለመቅረፍ እና የታካሚዎችን ደህንነት የሚያረጋግጡ ህጎች እንዲስተካከሉ እና ሥራ ላይ እንዲውሉ የበኩሎን አስተዋፅዖ ያበረክታሉ፡፡ ስምዎ በዚህ ጥናት ላይ አይፃፍም፡፡ ስለዚህም የእርሶ ምላሽ ሚስጥራዊነቱ የተጠበቀ ነው:: በዚህ መጠይቅ ላይ ለመሳተፍ መስማማትም ሆነ አለመስማማት ይችላሉ፡፡ ባለመስማማቶ ምንም የሚጎዱት ነገር የለም፡፡

ምንም አይነት ጥያቄ ካለዎት ቀጥሎ በተፃፈው አድራሻ ተመራማሪውን ማግኘት ይችላሉ፡፡ ጥያቄዉን ለመቀጠል ፍቃደኛ ኖት? ከተስማሙ ፊርማዎትን ያስቀምጡ፡፡

አዎ _____ አይደለሁ_____(ስለ ረዱኝ በድጋሚ አመሰግናለሁ)

አዲሱ ነጌሳ (ዋና ተመራማሪ):

ስልክ +251926437399

የመረጃ ሰብሳቢ ስም _____ፊርማ _____

የተቆጣጣሪ

ስም_____ፊርማ_____

የቃለ መጠየቁ ቀን_____

9.3. Annex III: Questionnaires

Dummy table of socio-demographic characteristics

S. No	Questions	Possible Responses
101	Age of the patient	
102	Weight	
103	Height	
104	BMI	

Dummy table of preoperative factors

S. No	Questions	Possible Responses (Tick, circle, or write)
201	Gestational age (in Weeks)	
202	Parity (in number)	
203	Indication for cesarean section	Preeclampsia (With/without Severity features)
		CPD
		Previous c/s scar
		Malpresentation
		Other: (Specify)_____
204	ASA Status	II
		III
205	Labor	Yes
		No

206	Baseline Systolic BP	1st measurement	2 minutes later
		_____mmHg	_____mmHg
207	Baseline Diastolic BP	_____mmHg	_____ mmHg
208	Baseline Mean Arterial Pressure	_____mmHg	_____mmHg
209	Anti- Hypertensive	Magnesium sulphate_____mg	
		Hydralazine _____ mg	
		Methyldopa _____ mg	
		Other:_____mg	
210	Fluid preloaded/ co-loaded	Ringer's Lactate _____ ml.	
		Normal Saline _____ml.	

Dummy Table of Intraoperative Factors

S. No	Question	Response
301	Dose of bupivacaine	_____ mg
302	Level of Sensory block(Circle one)	T4
		T5
		T6
		T7
		Other
303	Spinal puncture to baby delivery duration in minutes	
304	Baby weight	_____gram
305	Vasopressor used	Ephedrine _____mg
		Adrenaline _____ ug.
		Phenylephrine_____ ug.
		Other:_____
306	Total fluid used intraoperatively	_____ ml.
307	Estimated blood loss	_____ ml

Dummy Table of Intraoperative Vital Signs

S. No	Time	Systolic BP	Diastolic BP	MAP
401	3 minutes after SA			
402	6 minutes after SA			
403	9 minutes after SA			
404	12 minutes after SA			
405	15 minutes after SA			
406	18 minutes after SA			
407	21 minutes after SA			
408	26 minutes after SA			
409	31 minutes after SA			
410	36 minutes after SA			
411	41 minutes after SA			
412	45 Minutes after SA			
415	Duration of Surgery			

DECLARATION

I hereby declare that this MSc thesis entitled, “Incidence and predictors of hypotension after spinal anesthesia among preeclamptic mothers who underwent cesarean section in selected teaching hospitals of southern Ethiopia” is my original work and has not been presented for a degree in this or any other university, and that all sources of materials used for the thesis have been fully acknowledged.

Name of principal investigator: _____

Signature: _____

Name of the institution: _____

Date of submission: _____